

## 3 Study Area Description

The Ala Wai watershed is located on the southern shores of the island of O‘ahu and encompasses a land area of approximately 12,033 acres. The watershed generally includes those areas that lie between Punchbowl Crater (Pūowaina) and Diamond Head Crater (Lē‘ahi), and from the crest of the Ko‘olau Mountains to the near-shore reef.

Three upstream drainage areas feed the Ala Wai Canal: Makiki, 1,687 acres; Mānoa, and Pālolo, combined for 6,247 acres. The Mānoa and Pālolo drainages are evaluated together because Mānoa Stream and Pālolo Stream both feed into the Mānoa-Pālolo Drainage Canal. In addition to receiving drainage from Makiki, Mānoa, and Pālolo, the Ala Wai Canal also collects storm water runoff from the Kapahulu, Mō‘ili‘ili, Ala Moana, and Waikīkī areas (approximately 4,099 acres). See Figure 2 for a map of the sub-watersheds.

### 3.1 Climate

The typical northeasterly trade winds rise over the mountain ridges, therefore causing moisture to fall as rain. Rainfall quantities vary, with the upper portions of the Ko‘olau Mountains receiving an average of more than 158 inches/year and the lower portions near Waikīkī receiving an average of less than 25 inches/year.<sup>3</sup> Most rain falls during

the winter months, although substantial rain falls throughout the year.

### 3.2 Physical Features

The Ala Wai watershed lies on the southern slope of the extinct Ko‘olau volcano. Most of the volcanic flows that created this area are thought to be at least 100,000 years old. Lava flows from the top of the Ko‘olau mountains came down through the valleys and created the relatively flat floors evident in valleys such as Mānoa.<sup>4</sup> Today, the Ko‘olau Range is a highly eroded shield volcano with deep valleys and steep ridges in the interior sections. The altitude within the watershed ranges between sea level and 800 meters (2,438 feet).

Two soil groups may be found in the Ala Wai watershed. The Lualualei-fill land-Ewa association is a well-drained soil that may be found in the lower elevations. These soils have fine textured or moderately fine-textured subsoil or underlying material.<sup>5</sup>

The upper watershed is comprised of rock land-stony steep land association. These soils are generally found on steep to precipitous lands and are well-drained to excessively drained.<sup>6</sup>

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*Ala Wai Canal Watershed, Honolulu, Oahu, Hawaii.*

<sup>4</sup> Juvik, S. P., & Juvik, J. O. (Eds.). (1998). *Atlas of Hawai‘i: Third Edition*.

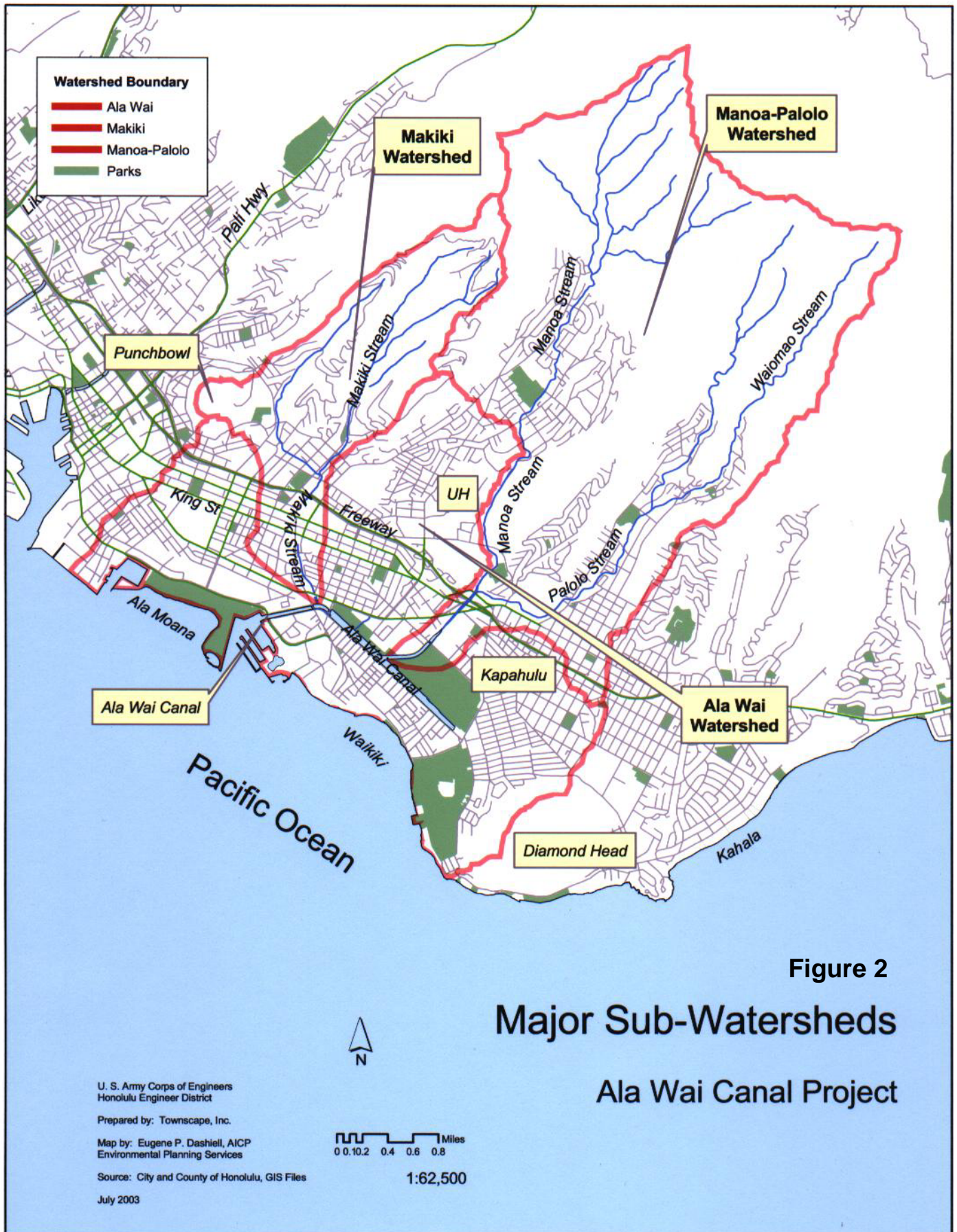
<sup>5</sup> U.S. Department of Agriculture Soil Conservation Service. (1972). *Soil Survey of Islands of Kauai, Oahu, Maui, Molokai, and Lanai, State of Hawaii*.

<sup>6</sup> Ibid.

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<sup>3</sup> State of Hawaii Department of Land and Natural Resources Division of Water and Land Development. (1992). *A Management Plan for the*

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### 3.3 Hydrology/Water Resources

High rainfall, an average of 158 inches per year, in the upper watershed contributes to the abundant water resources that may be found throughout the area.<sup>7</sup> In addition to surface water features such as streams, underground water features have also had notable impact on Hawaiian folklore and relatively recent development.

#### 3.3.1 Groundwater

About 92% of O'ahu's water comes from underground aquifers fed by rainfall along the Ko'olau and Wai'anae mountain ranges.<sup>8</sup> The sustainable yield for the island of O'ahu is 446 millions of gallons per day (mgd), of which, the Honolulu Aquifer, extending from Moanalua to Koko Head, provides a sustainable yield of 53 mgd.<sup>9</sup> The Ala Wai watershed area contributes to both the Nu'uuanu Aquifer, with a sustainable yield of 15 mgd, and the Pālolo Aquifer, with a sustainable yield of 5 mgd (Honolulu Board of Water Supply, personal communication, March 17, 2003).

An interesting feature in the Ala Wai watershed is the Mō'ili'ili Karst, an underground landform that was created by the dissolution of soluble rocks by water. This karst is approximately one kilometer square and is located under the King Street-

University Avenue area.<sup>10</sup> This system of drainage caves was believed to have fed several ponds in the area including the Kānewai and Kumulae (Hausten) Springs. A 1994 survey of the karst produced accounts of cool, clear water and the presence of fish, despite evidence of human intrusion, such as construction fill, metal pilings, and trash swept into the system by floodwaters.<sup>11</sup>

#### 3.3.2 Surface Water and Modifications

Hawai'i experiences high rainfall, but most streams do not flow continuously throughout the year due to the high permeability of the rocks and soils.<sup>12</sup> However, the steep slopes typical of watersheds in Hawai'i create conditions of "high peak flows with a sharp rise and recession."<sup>13</sup> This makes streams prone to flash flooding during storm events.

In 1990, the National Park Service, Hawai'i Cooperative Park Service Unit developed the Hawai'i Stream Assessment: A Preliminary Appraisal of Hawaii's Stream Resources for the State of Hawai'i Department of Land and Natural Resources Commission on Water Resource Management. The assessment defines streams as "separate entities when they have a separate mouth to the sea." Systems include those streams that have tributaries that extend into distinctly different valleys,

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<sup>7</sup> State of Hawaii Department of Land and Natural Resources Division of Water and Land Development. (1992). *A Management Plan for the Ala Wai Canal Watershed, Honolulu, Oahu, Hawaii*.

<sup>8</sup> Honolulu Board of Water Supply website. <http://www.hbws.org>

<sup>9</sup> Honolulu Board of Water Supply website. [http://www.hbws.org/ea\\_wat\\_resource/DPMaps.pdf](http://www.hbws.org/ea_wat_resource/DPMaps.pdf)

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<sup>10</sup> Halliday, William R. (1998). History and Status of the Moiliili Karst, Hawai'i.

<sup>11</sup> Ibid.

<sup>12</sup> US Army Corps of Engineers. (1992). *Urban Flood Control Study, Honolulu, Hawaii Final Reconnaissance Report Main Report*.

<sup>13</sup> Ibid.



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but share an outlet.<sup>14</sup> The streams of the Ala Wai watershed are considered to be a part of a system.

The Hawai'i Stream assessment also classifies streams as perennial or intermittent. Perennial streams are those that typically have surface flow throughout the year in all or part of its length and intermittent streams are normally dry for part of the year. The Ala Wai system, including Makiki, Mānoa, and Pālolo streams, is considered perennial.<sup>15</sup> Timbol and Maciolek (1978) further classify Makiki Stream as interrupted and Mānoa Stream as continuous.<sup>16</sup> Continuous streams naturally flow to the sea year-round. Interrupted streams have intermittent flow in a portion or portions of the channel, and discharges into the sea during the wet season or during storm flows.

Over the decades, man's alteration of the surface water systems of the Ala Wai watershed to safeguard development from flooding has changed the natural drainage patterns of the area. All three major stream systems have been altered, as well as the waterway they drain into, the Ala Wai Canal. Typical stream channel modifications include lined channels, elevated culverts, revetments, blocked or filled-in channels, and extended culverts.

**Makiki Stream.** Makiki Stream is approximately 3.5 miles long, and its tributaries include Kanahā Stream, Kanealole Stream, Moleka Stream, and Maunalaha Stream. The peak discharge was calculated to be 5,600 cubic feet per second (cfs), although actual stream flow data are not available due to the lack of stream gauges.<sup>17</sup>

Makiki Stream was originally modified in 1930 for flood protection, channelizing from Ala Wai Canal to King Street with concrete rubble masonry (crm) walls on both banks.<sup>18</sup>

Kanahā Stream, the main tributary, connects to Makiki Stream via Makiki Ditch, a 6,400 foot long lateral channel.<sup>19</sup> Modifications downstream of the Kanahā Stream-Makiki



*Makiki Stream downstream of the Onee Bridge.*

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<sup>14</sup> State of Hawaii Department of Land and Natural Resources Commission on Water Resource Management. (1990). *Hawaii Stream Assessment: A Preliminary Appraisal of Hawaii's Stream Resources*.

<sup>15</sup> U.S. Fish and Wildlife Service. (1978). *Stream Channel Modification in Hawaii*.

<sup>16</sup> Ibid.

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<sup>17</sup> City and County of Honolulu. (1975). *Engineering Report of Alternative Structural Schemes for Makiki Stream Flood Control Unit I at Honolulu, Oahu, Hawaii*.

<sup>18</sup> Committee on Hydrology. (2001). *Ala Wai Canal, Honolulu, Hawaii*.

<sup>19</sup> State of Hawaii Department of Land and Natural Resources Division of Water and Land Development. (1983). *Flood Control and Flood Water Conservation in Hawaii Volume II: General Flood Control Plan for Hawai'i*.

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#### Types of Stream Modifications<sup>20</sup>

Modification	Definition
Lined Channel	Artificial channel where the natural banks and stream bed have been replaced, usually with concrete. Channel may have a flat or v-shaped bottom.
Vegetation removed-channel realigned	Stream has been realigned and riparian vegetation cleared.
Elevated culvert	Relatively short (typically less than 60 meters) conduit structures that are usually found under highways. They are built well above the water level immediately downstream, creating an artificial waterfall.
Revetment	One or both banks of the stream are reinforced, but the channel is not.
Blocked or filled-in channel	Part of the original channel is blocked.
Extended culvert	Similar to but longer than elevated culverts; usually found in residential areas.

Stream confluence include revetments, lined channels, extended culverts, and elevated culverts.<sup>21</sup>

**Mānoa Stream.** Mānoa Stream drains the largest of the three stream basins, and runs for approximately 3.5 miles from the top of the Urban District to its confluence with the Ala Wai Canal. Most of Mānoa Stream's tributaries lie within the state Conservation District and include 'Aihualama, Waihi, Lua'alaea, Nāniu'apo, and Waiakeakua Streams.

<sup>20</sup> U.S. Fish and Wildlife Service. (1978). *Stream Channel Modification in Hawaii*.

<sup>21</sup> Ibid.

In 1952, the City constructed approximately 1,000 feet of reinforced concrete channel upstream of East Mānoa Road.<sup>22</sup> Modifications for both upstream and downstream sections of these original alterations were designed in the 1970's but were never constructed.

Additional modifications include a rock wall that the State and City constructed jointly along an eroded section of Mānoa Stream near the Mānoa Village Condominium. In 1989, the Mānoa Marketplace owner constructed about 160 feet of grouted rubble rock face on the makai side of the stream near the old KC Drive-In Restaurant. Another minor improvement was a 10-foot by 75-foot thin concrete layer and cm wall constructed in 1993-1994 within the property downstream and adjacent to the Mānoa Village Condominium property.<sup>23</sup> Bridges crossing Mānoa Stream were constructed at East Mānoa Road (1949), Lowrey Avenue (1952), Kahaloa Drive (1953), & Woodlawn Drive (1974).<sup>24</sup>



*Mānoa Stream near the Mānoa District Park.*

<sup>22</sup> State of Hawaii Department of Land and Natural Resources Division of Water and Land Development. (1995). *A Study to Alleviate Flooding of Manoa Stream (East Manoa Road to Woodlawn Drive) Island of Oahu*.

<sup>23</sup> Ibid.

<sup>24</sup> Ibid.

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*Pālolo Stream downstream of the Kiwila Bridge.*

**Pālolo Stream.** Pukele Stream extends high into the Conservation District and joins with Wai‘ōma‘o Stream to create Pālolo Stream near Pālolo Elementary School. Pālolo Stream has been substantially modified in the Urban District, except for a section from St. Louis Drive to Keanu Street.<sup>25</sup> These alterations include lined channels and a revetment.<sup>26</sup>

**Mānoa-Pālolo Drainage Canal.** Pālolo Stream meets Mānoa Stream above Wai‘alae Avenue at the Mānoa-Pālolo Drainage Canal (MPDC). The 1.3-mile long MPDC was created in 1935 to combine several meandering streams into one straight outlet to the Ala Wai Canal.<sup>27</sup>

It is lined in the upstream area and unlined above its confluence with the Ala Wai Canal.<sup>28</sup> Large amounts of silt accumulate in the unlined section of the MPDC, making its depth only 0 to -0.5 feet msl.<sup>29</sup> The MPDC has a width of 125 feet. Its capacity is 5,000 cubic feet per second (cfs) in the area just upstream of the Date Street Bridge, which was projected to be less than the 10-year flood capacity.<sup>30</sup>



*Mānoa-Pālolo Drainage Canal near Kaimuki High School.*

**Ala Wai Canal.** The Ala Wai Canal is an approximately 2-mile long manmade waterway that was created to enable land reclamation for development purposes. Waikīkī was previously a wetland and estuary, and was converted into taro *lo‘i* (irrigated terraces), fish ponds, and later duck ponds. Lucius E. Pinkham, president of the Board of Health, proposed the

<sup>25</sup> State of Hawaii Department of Land and Natural Resources Division of Water and Land Development. (1983). *Flood Control and Flood Water Conservation in Hawaii Volume II: General Flood Control Plan for Hawai‘i*.

<sup>26</sup> U.S. Fish and Wildlife Service. (1978). *Stream Channel Modification in Hawaii*.

<sup>27</sup> State of Hawaii Department of Land and Natural Resources Division of Water and Land Development. (1992). *A Management Plan for the Ala Wai Canal Watershed, Honolulu, Oahu, Hawaii*.

<sup>28</sup> State of Hawaii Department of Land and Natural Resources. (1977). *Preliminary Engineering Report for Dredging Ala Wai Canal, Island of Oahu*.

<sup>29</sup> Ibid.

<sup>30</sup> Committee on Hydrology. (2001). *Ala Wai Canal, Honolulu, Hawai‘i*.



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*Aerial view of the Ala Wai Canal.*

Waikīkī Reclamation Project to enhance the residential development that had begun to emerge in this area by providing land, reducing breeding grounds for mosquitoes, and improving aesthetics.<sup>31</sup> This reclamation project culminated in the development of the Ala Wai Canal in 1920-1924.<sup>32</sup> The natural drainage patterns in the Ala Wai watershed area have been severely altered by storm drains that empty into existing streams and the Ala Wai Canal.

The length of Canal from the Ala Moana Boulevard Bridge to the Kalākaua Avenue Bridge has an average width of 158 feet. The Canal widens to 260 feet between Kalākaua Avenue and McCully Street, and remains that width until it tapers back down to 160 feet inland of the confluence with the Mānoa-Pālolo Drainage Canal (MPDC).

Initially dredged to a depth of -10.0 to -25.0 feet mean sea level (msl), sedimentation has since decreased Canal depths to -10.0 feet msl near the Ala Wai Harbor and -2.0 feet msl at the confluence with the MPDC.<sup>33</sup> The shallow depth near the MPDC is due to sedimentation from the upper watershed, which has reduced the carrying capacity of the Canal. The bank-full capacity has been estimated to be 6,500 cfs at a location 2,000 feet upstream of the confluence.<sup>34</sup>

The recommended dredging frequency is every ten years, although the last dredging occurred in 1978-1979, a period of 24 years. Dredging is currently ongoing; it began in August of 2002 and is expected to be completed in mid to late 2003. An estimated 170,000 cubic yards of sediment is expected to be removed from the Ala Wai and Mānoa-Pālolo Drainage Canals at a cost of \$7.4 million.<sup>35</sup> This dredging effort is intended to return the Canal to a depth of -6 to -12 msl.

**Ala Wai Harbor.** The Ala Wai Harbor was constructed by the U.S. Armed Forces in the early 1900's. A channel originally connected the harbor to Fort DeRussy in Waikīkī, but was later filled in, and the Ala Wai Canal and harbor were connected.<sup>36</sup>

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<sup>31</sup> State of Hawaii Department of Land and Natural Resources. (1977). *Negative Declaration and Environmental Impact Assessment for the Proposed Ala Wai Dredging, Oahu, Hawaii.*

<sup>32</sup> State of Hawaii Department of Land and Natural Resources Division of Water and Land Development. (1992). *A Management Plan for the Ala Wai Canal Watershed, Honolulu, Oahu, Hawaii.*

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<sup>33</sup> City and County of Honolulu Department of Transportation Services/Department of Design and Construction. (1998). *Ala Wai Canal Dredging Final Environmental Assessment.*

<sup>34</sup> Committee on Hydrology. (2001). *Ala Wai Canal, Honolulu, Hawai'i.*

<sup>35</sup> Leone, Diana. (2000, August 4). Dredging the Ala Wai Canal. [Electronic Version].

<sup>36</sup> State of Hawaii Department of Transportation. (1972). *The Environmental Impacts of the Proposed Construction (Phase I) for the Ala Wai Boat Harbor Final Environmental Statement.*

Since then, the harbor has grown incrementally in response to increasing numbers of recreational boat owners.

The DOH classifies the Ala Wai Boat Harbor as a Class A embayment that should be protected “for recreational purposes and aesthetic enjoyment.”<sup>37</sup> The Ala Wai Boat Harbor is also classified as a Class 2 artificial basin. Class 2 waters are protected “for recreational purposes, the support and propagation of aquatic life, agricultural and industrial water supplies, shipping and navigation.”<sup>38</sup>

**Surface Water Quality.** The Federal Clean Water Act §303(d) mandates that each state is required to submit to the USEPA a list of water bodies that are not expected to meet state water quality standards, even after action is taken to control non-point source pollution. In 1998, the Ala Wai Canal was listed as one of Hawaii’s Water Quality Limited Segments (WQLS) for nutrients, metals, suspended solids, pathogens and turbidity. The Draft 2002 List of Impaired Water Bodies includes Makiki Stream for Phosphorous (P) and Nitrogen (N); Mānoa Stream for nutrients, turbidity, dieltrin, and total chlordan; Pālolo Stream for trash; and the Ala Wai Canal and Harbor for nutrients, pathogens, metals, turbidity, suspended solids, organochlorine pesticides, lead, enterococci, N, P, chlorophyll-a, and fecal coliform.<sup>39</sup>

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<sup>37</sup> State of Hawaii Department of Health. (2000). *Hawaii Administrative Rules, Title 11, Department of Health, Chapter 54 Water Quality Standards.*

<sup>38</sup> Ibid.

<sup>39</sup> State of Hawaii Department of Health Environmental Planning Office. (2002). *Final 2002*

## 3.4 Near-Shore Waters

Water from the entire watershed eventually empties into the near-shore marine waters. Therefore, problems that occur in the upstream regions ultimately affect the waters of Māmala Bay and Waikīkī, making them an important component of the watershed.

### 3.4.1 Māmala Bay

Māmala Bay is the water body that encompasses the area offshore of southern O’ahu from Kalaeloa (Barbers Point) to Diamond Head. Water quality in Māmala Bay has been impacted due to point and non-point source discharges. To address this, the State of Hawai’i has numerous programs to mitigate pollution in the Bay. The Māmala Bay Study found that damage to reef and reef ecosystems was more the result of habitat alteration than from wastewater related pollution.<sup>40</sup>

### 3.4.2 Beaches and Coral Reefs

Waikīkī was historically a series of swamps, lo’i, and fish ponds. Over time, the wetlands have been filled with dredged coral material. This has culminated in the development of approximately 10,800 feet of primarily man-made or enhanced beach that extends from the Ala Wai Harbor to the residential apartment area fronting

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*List of Impaired Waters in Hawai’i Prepared Under Clean Water Act §303(d).*

<sup>40</sup> Mamala Bay Study Commission. (1996). *Mamala Bay Study Final Report.*



Kapi‘olani Park.<sup>41</sup> These beaches have been subject to extensive erosion.<sup>42</sup>

Modifications to the shoreline include several groins, storm drains, seawalls, a natatorium, and assorted private and public structures associated with the beaches such as bathhouses.<sup>43</sup> The Waikīkī Aquarium and the Elks Club, and several large hotels are also built near the shoreline.

Offshore of Waikīkī, a 1,000- to 2,000-foot wide coral reef fringes the beach and is often exposed at low tide. Fresh water from the Mānoa-Pālolo watershed inhibited coral growth off of Kūhiō Beach, creating a channel. Beyond the reef, the coral shelf drops rapidly to reach a depth of approximately 600 feet only 1.5 miles off shore.<sup>44</sup>

Several beaches are included in the Draft 2002 List of Impaired Water Bodies. Listed water bodies include Gray’s Beach for N, turbidity and chlorophyll-a; Kahanamoku Lagoon for enterococci; Kūhiō Beach for enterococci; and Māmala Bay for N, chlorophyll-a, and enterococci.<sup>45</sup> All of these waters were considered low priority

for Total Maximum Daily Load (TMDL) development.

## 3.5 Biotic Resources

Little is known about the biotic resources of the watershed. Research is fragmented and often discusses a particular species or location, rather than whole ecosystems. Some threats and mitigative or corrective measures have been identified, although more data are needed to fully understand the interconnected processes that are occurring. What is known is that the Ala Wai ecosystems are highly disturbed, even in the forested portions of the upper watershed.

### 3.5.1 Terrestrial Ecosystem

The lower areas of the watershed are highly urbanized and are dominated by introduced weeds, shrubs and trees. Typical fauna in the urbanized area include introduced species such as domesticated cats and dogs, rats, and birds.

The upper areas of the watershed, above the urban developed lands, are a part of the Honolulu Watershed Forest Reserve. Vegetation types include native lowland dry forest and shrubland, lowland mesic forest and shrubland and lowland wet forest and shrubland. The Hawai‘i Stream Assessment (1990) identified the Ala Wai System as having only 10% native forest.

The common moorhen, *Gallinula chloropus sandvicensis*, is an endangered species that

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<sup>41</sup> Crane, Jerald K. (1972). *History of the Marine Structures on Waikiki Beach and Their Effects Upon the Beach*.

<sup>42</sup> City and County of Honolulu Department of General Planning. (1992). *Waikiki Master Plan*.

<sup>43</sup> Crane, Jerald K. (1972). *History of the Marine Structures on Waikiki Beach and Their Effects Upon the Beach*.

<sup>44</sup> Ibid.

<sup>45</sup> State of Hawaii Department of Health Environmental Planning Office. (2002). *Final 2002 List of Impaired Waters in Hawai‘i Prepared Under Clean Water Act §303(d)*.

has been observed near the MPDC.<sup>46</sup> Some water birds, seabirds, and migratory shorebirds have been observed or been known to occur near the Ala Wai Canal or MPDC.<sup>47</sup>

The O‘ahu ‘elepaio is a small flycatcher that was placed on the USFWS list of endangered species in 2000.<sup>48</sup> Critical habitat is defined as those areas that are essential to the recovery and perpetuation of a threatened or endangered species. Portions of the Honolulu Watershed Forest Reserve are designated as ‘elepaio critical habitat.

The forest reserve is plagued by alien plant species, many of which are invasive, including *Miconia calvescens*, *Pennisetum setaceum* (Fountain grass), *Prosopis juliflora* (Thorny kiawe), and *Rubus discolor* (Himalayan blackberry).<sup>49</sup> Alien plants are suspected of out competing native plants for resources and providing a canopy that is inferior to native forest cover in terms of protecting the ground against soil erosion.

Introduced animals also cause harm to the native ecosystem. Of special concern are rats and pigs, which pose direct threats to both native plants and birds. Rats not only eat the seeds of some native plants, but also prey upon forest birds such as ‘elepaio. Pigs

eat young plants, therefore destroying the under story and increasing soil erosion. They also uproot trees and create wallows, which provide breeding grounds for mosquitoes that may serve as vectors for avian diseases such as malaria.

#### 3.5.2 Aquatic and Riparian Ecosystem

The Hawai‘i Stream Assessment identified 376 perennial streams in Hawai‘i; of these only 164 (44%) had some biological information. On a scale including the categories Outstanding, Substantial, Moderate, Limited, Without Data, and Unknown, the Ala Wai System was ranked as “moderate” in terms of aquatic resources, meaning that at least one native species from the indicator species group was observed.<sup>50</sup> A total of nine native species and thirteen introduced species were observed at the time of that report.<sup>51</sup>

The aquatic habitat within this watershed is highly impacted by in-stream modifications, adjacent development, poor water quality, and the introduction and proliferation of alien species. Despite this, some native species still manage to survive, although anecdotal evidence suggests that their numbers are declining as alien species increasingly dominate the streams.

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<sup>46</sup> City and County of Honolulu Department of Transportation Services/Department of Design and Construction. (1998). *Ala Wai Canal Dredging Final Environmental Assessment*

<sup>47</sup> Ibid.

<sup>48</sup> U.S. Fish and Wildlife Service. (2001). *Critical Habitat for the O‘ahu ‘Elapaio*. Honolulu, HI.

<sup>49</sup> O‘ahu Invasive Species Committee website <http://www.hear.org/oisc/>

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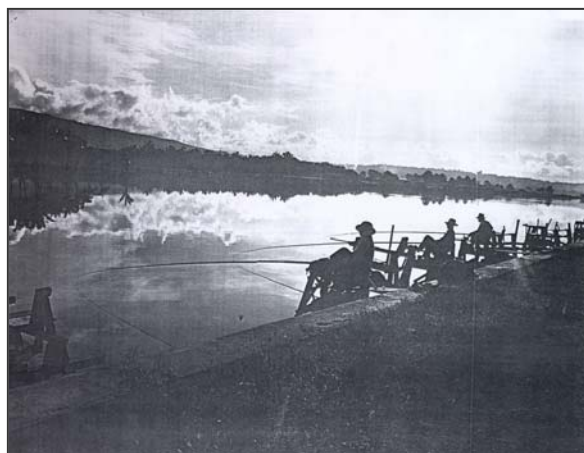
<sup>50</sup> State of Hawaii Department of Land and Natural Resources Commission on Water Resource Management. (1990). *Hawaii Stream Assessment: A Preliminary Appraisal of Hawaii’s Stream Resources*.

<sup>51</sup> State of Hawaii Department of Land and Natural Resources and University of Hawaii Cooperative National Park Resources Study Unit. (1990). *Hawaii Stream Assessment Aquatic Resources Volume I: Methods, Bibliography & Data Sheets for Kauai & Oahu*.

#### 3.5.3 Estuarine Ecosystem

The Ala Wai Canal itself is considered an estuary, defined as “characteristically brackish waters in well-defined basins with a continuous or seasonal surface connection to the ocean that allows entry of marine fauna.”<sup>52</sup> The Ala Wai Boat Harbor is considered an embayment, “a land-confined and physically protected marine water with restricted openings to open coastal waters, defined by the ratio of total bay volume to the cross-sectional entrance area of seven hundred to one or greater.”<sup>53</sup> Estuaries and embayments are important as habitat for larval and juvenile stages of some native species such as *o‘opu* and ‘*ama‘ama*, or mullet.

A 1975 study of the Ala Wai Canal biota found “a profuse and varied zooplankton fauna,” five species of crustaceans, and twenty-one species of fish, eleven of which are considered of recreational importance.<sup>54</sup>



*Mullet fishermen at the Ala Wai Canal circa 1920s.*

<sup>52</sup> State of Hawaii Department of Health. (2000). *Hawaii Administrative Rules, Title 11, Department of Health, Chapter 54 Water Quality Standards.*

<sup>53</sup> Ibid.

Oxygen concentration was found to be the parameter that dictated the distribution of species in the Canal.<sup>55</sup>

Subsequent studies have found a less diverse ecosystem that is attributed to the degradation in water quality and habitat in the Canal. Alien species such as tilapia (*Tilapia Mozambique*) have become a prominent member of the Canal fauna, due to their ability to survive in slow moving, low oxygen waters. Other organisms that may still be found in the Canal include young trevally (family *Carangidae*), barracuda (*Sphyraena barracuda*), Hawaiian flagtail (*Kuhlia sandvicensis*), bonefish (*Abula glossodonta*), mullet (*Mugil cephalus*), Samoan crab (*Scylla serrator*), blue pincer crab (*Thalamita crenata*), and mantis shrimp (*Odontodactylus Scyllarus*).<sup>56</sup>

#### 3.5.4 Marine Ecosystem

The DLNR has recognized the importance of the near-shore waters by designating portions of it as a Marine Life Conservation District and a Fishery Management Area. Marine Life Conservation Districts are managed by the DLNR DAR “to protect, conserve, and propagate marine life by prohibiting or limiting consumptive uses of the marine resources.”<sup>57</sup> Waikīkī Marine Life Conservation District covers 76 acres

<sup>54</sup> Miller, Jacquelin N. (1975). *Ecological Studies of the Biota of the Ala Wai Canal.*

<sup>55</sup> Ibid.

<sup>56</sup> State of Hawaii Department of Health. (1997). *Fishing Practices of the Ala Wai Canal.*

<sup>57</sup> State of Hawaii Department of Land and Natural Resources Commission on Water Resource Management. (1990). *Hawaii Stream Assessment: A Preliminary Appraisal of Hawaii's Stream Resources.*



and was established in 1988. It covers the area from the Waikīkī War Memorial Natatorium to the Kapahulu Avenue groin and from the shoreline to 500 yards seaward or the edge of the fringing reef, whichever is greater.<sup>58</sup> Fishery Management Areas are also coordinated by the DLNR to “enhance and improve recreational fishing by restricting certain types of fishing activities within the high water marked boundaries of the area.”<sup>59</sup> The Ala Wai System is one of three stream-associated Fishery Management Areas identified on O‘ahu.

The waters off of Waikīkī through Makapu‘u are also designated as a part of the Hawaiian Islands Humpback Whale National Marine Sanctuary. This sanctuary does not have any regulations tied to its designation, but it does encourage uses that are compatible with its vision to “sustain a safe and healthy habitat for the North Pacific stock of humpback whales (*koholā*).”<sup>60</sup>

## 3.6 Historic Conditions

One of the objectives of the Ala Wai Project is to restore the natural ecosystem. While true pristine conditions can never be known

or achieved, a review of some historical narratives, maps, and native Hawaiian oral traditions may provide some understanding of the past, less altered ecosystem, and thus provide benchmarks for restoration.

The Ala Wai watershed includes three *ahupua‘a*, Makiki, Mānoa, and Pālolo, located in the central region of the Kona District of O‘ahu. The entire Kona District includes fifteen *ahupua‘a* and extends from Moanalua to Maunaloa, currently known as Hawai‘i Kai.

The densest populations on O‘ahu were in those areas adjoining Waikīkī, where ali‘i, Hawaiian chiefs, typically held residences. Those areas surrounding Waikīkī were abundant with rain, perennial streams, springs, pools, lush interior valleys, broad slopes and well-watered lowlands, fish pond areas, harbors, beaches and lagoons. Kona, O‘ahu was considered the area richest in natural resources. See Figure 3 for a map of some historic conditions.

### 3.6.1 Makiki *Ahupua‘a*

Makiki is the westernmost *ahupua‘a* of the Ala Wai system and was likely named after the types of stones that were used as weights for octopus lures.<sup>61</sup> The valley was steep and covered with volcanic cinders. Rain fell year-round, contributing to swamp lands in the lower elevations.

### 3.6.2 Mānoa *Ahupua‘a*

Mānoa is a large valley whose name literally translates as “vast.” Chiefs are said to have

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<sup>58</sup> State of Hawaii Department of Land and Natural Resources Division of Aquatic Resources. (1988). *Hawaii Administrative Rules, Title 13, Department of Land and Natural Resources, Subtitle 4, Fisheries, Chapter 36 Waikiki Marine Life Conservation District, Oahu.*

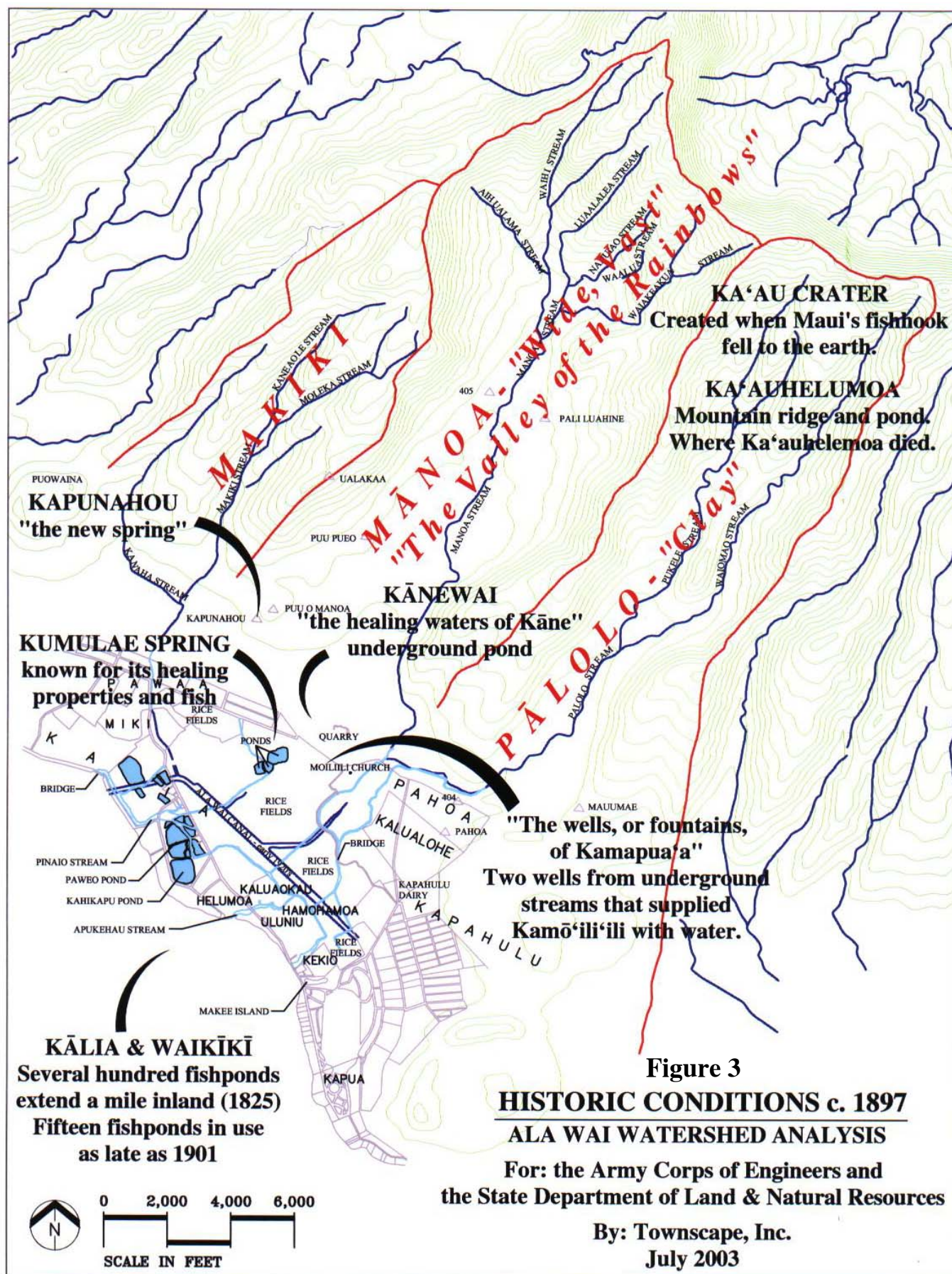
<sup>59</sup> State of Hawaii Department of Land and Natural Resources Commission on Water Resource Management. (1990). *Hawaii Stream Assessment: A Preliminary Appraisal of Hawaii’s Stream Resources.*

<sup>60</sup> Hawaiian Islands Humpback Whale National Marine Sanctuary website  
<http://www.hihwnms.nos.noaa.gov/>

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<sup>61</sup> Pukui, M. K., Elbert, S. H., & Mookini, E. T. (1974). *Place Names of Hawaii.*

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lived in the western half of the valley, and commoners in the eastern half.<sup>62</sup> Many Mānoa stories involve water, especially underground water sources.

Kānewai was a large underground pond that was sought by the Hawaiians for its healing properties. Literally translated as “the waters of Kāne,” it was said that fish would swim to the pool from the sea to overhear fishermen’s plans.<sup>63</sup> Kumulae Spring was said to have healing properties and be a favorite bathing ground for a princess. The spring also provided clean water for the arid plain, an abundance of “plump fish,” and squid.<sup>64</sup> This spring was later named Hausten Pond, after the man who purchased the land in the 1920’s. The Willows Restaurant was built around the pond, and its fish were considered a main attraction. Pumping of the underground water system in 1934 has dried up the pond, which has since been lined with concrete.

The demigod Kamapua‘a is said to have dug through stones and soil in pursuit of two beautiful women in Mānoa. After penetrating the underlying layer of petrified coral, a flood of water burst through to stop Kamapua‘a. Since then, the two wells have supplied Kamō‘ili‘ili with water and bear the name “The wells, or fountains, of Kamapua‘a.”<sup>65</sup>

Kapunahou, “the new spring,” was created after the god Kāne thrust his staff into the

ground and caused underground water to erupt to the surface. Another story of the origin of the spring tells of an elderly man and woman that, through directions given them in dreams, uncovered a spring at the base of a hala tree.<sup>66</sup>

Hipiwai Cave is an underground cavern said to have “much of the water of Mānoa passing through it.”<sup>67</sup> Waiakeakua, is a swimming pool at the head of Mānoa Valley that was created by the god Kāne and literally translates as “water used by the god.”<sup>68</sup>

The upper valley produced such plants as pandanus, ti, yams, mountain apple, potato, black nightshade, taro, milkweed, hibiscus, Eugenia, coconut, ‘ōhi‘a, hau, guava, and kava. Terraces lined Mānoa Stream and taro flats dominated the lower portions of the valley.

#### 3.6.3 Pālolo Ahupua‘a

The name Pālolo literally means “clay,” presumably from the type of soil found there.<sup>69</sup> Ka‘au Crater is believed to have been created when Maui’s fish hook dropped to the Earth after Maui’s unsuccessful attempt to assemble the islands into one large land mass.<sup>70</sup>

Ka‘auhelumoa is a spring at the head of Pālolo Valley where the supernatural cock,

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<sup>62</sup> Sterling, E. P. & Summers, C. C. (1978). *Sites of O‘ahu*.

<sup>63</sup> Ibid.

<sup>64</sup> Ibid.

<sup>65</sup> Ibid.

<sup>66</sup> Ibid.

<sup>67</sup> Ibid.

<sup>68</sup> Ibid.

<sup>69</sup> Pukui, M. K., et. al. (1974). *Place Names of Hawaii*.

<sup>70</sup> Sterling, E. P. & Summers, C. C. (1978). *Sites of O‘ahu*.



Ka‘auhelumoa, died.<sup>71</sup> This spring is reported to seem red, as if colored by blood.

Terraces extended throughout the lower elevations of the valley, where taro was grown. Sandalwood grew in the upper areas and banana, taro, kukui, and mangoes could be found in the lower areas.

#### 3.6.4 Waikīkī

Waikīkī was where chiefs of O‘ahu made their home until the 1800’s when Kamehameha I moved to Honolulu. A reef protected the beach and provided access for canoes. Taro *lo‘i* (terraces) and *loko i‘a* (fish ponds) covered the landscape and were fed by springs, giving the definition of the name Waikīkī, “Spouting Waters.”<sup>72</sup> Accounts dating back to 1825 recall several hundred fish ponds in Waikīkī that extended a mile inland and as many as fifteen fish ponds were still present as late as 1901.<sup>73</sup>

The landscape of Waikīkī has been drastically altered from its previous condition, even as late as 1900. Not only were there fish ponds and *lo‘i* terraces where hotels sit today, but some of the streams had different alignments as well. Mānoa and Pālolo Streams joined and divided several times before emptying into the near-shore waters as ‘Āpuakēhau Stream until they were realigned in the early 1900’s. The marshlands of Waikīkī collected fine sediments that were transported from the uplands of Makiki, Mānoa, and Pālolo.

Flora and fauna included taro, yams, sweet potato, sugar cane, cloth plant, coconut palms, *‘ilima*, turtles, ducks, and other water fowl.

#### 3.6.5 Planning Implications

The Ala Wai area, including the *ahupua‘a* of Makiki, Mānoa, and Pālolo, were abundant with both surface and underground water. Mānoa was especially full of stories related to water, and many of the Hawaiian place names describe the waters found there. Examples include Waikīkī, Spouting Waters; Kānewai, the Waters of Kāne; and Kapunahou, the New Spring.

Stories also tell of clear waters, and plentiful fish, suggesting that the streams were clean and provided habitat for *o‘opu*, the native fresh water fish. The presence of the coral reef hints that the near-shore waters were clear and a source of fish for the people that settled there. These accounts provide references for future restoration actions, such as improving water quality, restoring sediment collection functions, and providing habitat for native species.

#### 3.7 Socio-Economic Resources

The Ala Wai watershed is an area that provides a variety of employment, residential, and recreational opportunities. Especially significant are the tourism-related activities of Waikīkī and the water-related activities associated with the Ala Wai Canal, Harbor, and beaches.

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<sup>71</sup> Ibid.

<sup>72</sup> Hibbard, D. & Franzen, D. (1986). *The View From Diamond Head: Royal Residence to Urban Resort*.

<sup>73</sup> Kanahele, G. S. (1995). *Waikīkī 100 B.B. to 1900 A.D.: An Untold Story*.

#### 3.7.1 Socio-Economics

The C&C Department of Planning and Permitting (DPP) identifies eight neighborhoods in the Ala Wai watershed: Ala Moana/Kaka‘ako, Makiki / Lower Punchbowl / Tantalus, Waikīkī, McCully/Mō‘ili‘ili, Mānoa, Pālolo, Diamond Head/Kapahulu/St. Louis, and Kaimukī.

All of the neighborhoods are densely populated. High-rise apartments and hotels dominate Waikīkī, as well as parts of Ala Moana/Kaka‘ako, McCully/Mō‘ili‘ili, and Makiki/Lower Punchbowl/Tantalus. The remaining neighborhoods tend to consist of single family homes.

Major economic activities that occur within the Ala Wai watershed include those related to tourism, golf, retail sales, and conventions. Waikīkī is a tourism center

and had a 2001 occupancy rate of 73.14%, which was higher than the state rate of 71.94%.<sup>75</sup> The Ala Wai Golf Course is run by the City and County of Honolulu and generated over \$2 million in revenue in fiscal year 1997.<sup>76</sup> Ala Moana Shopping Center annually grosses approximately \$1,000 to \$1,200 per square foot, making it one of the world’s most productive malls.<sup>77</sup> According to its Environmental Impact Statement, the Hawai‘i Convention Center is expected to draw an additional 8,000 to 8,900 visitors per year to O‘ahu and 13,200 to 16,300 to the state.<sup>78</sup>

#### 3.7.2 Recreational Resources

The Ala Wai Watershed is heavily used for recreational purposes, not only for activities in the Canal itself, but also for other activities in its mauka regions such as hiking and hunting. Its location in urban Honolulu and near the tourist center Waikīkī, make the recreational demand on the Ala Wai Watershed one of the highest in the state. The watershed provides for eight of nine recreational opportunities identified by the Hawai‘i Stream Assessment and was ranked “Outstanding” by the Regional Committee

#### 2000 Neighborhood Populations<sup>74</sup>

Neighborhood	Population
Ala Moana/Kaka‘ako	14,186
Makiki/Lower Punchbowl/ Tantalus	30,145
Waikīkī	19,720
McCully/Mō‘ili‘ili	26,122
Mānoa	21,184
Pālolo	13,091
Diamond/Kapahulu/St. Louis	19,137
Kaimukī	18,063
<b>Total</b>	<b>161,648</b>

<sup>74</sup> City and County of Honolulu Department of Planning and Permitting website <http://honolulu.dpp.org/planning/demographics/cp-toc.pdf>.

<sup>75</sup> State of Hawaii Department of Business, Economic Development and Tourism. (2001). *The State of Hawaii Data Book: A Statistical Abstract*.

<sup>76</sup> City and County of Honolulu Department of Transportation Services/Department of Design and Construction. (1998). *Ala Wai Canal Dredging Final Environmental Assessment*.

<sup>77</sup> International Council of Shopping Centers. (2003, January). *General Growth’s retail acquisitions in Honolulu are just the beginning, executives say*.

<sup>78</sup> City and County of Honolulu Department of Transportation Services/Department of Design and Construction. (1998). *Ala Wai Canal Dredging Final Environmental Assessment*.

on Recreational Resources.<sup>79</sup> However, recreational activities are affected by the condition of the watershed, usually in the form of poor water quality.

The Ala Wai Canal is heavily used for such activities as fishing, crabbing, jogging, walking, and kayak and canoe paddling. Water activities are affected by bacteria in the water that have been suggested to cause skin and intestinal infections. Consumption of organisms caught in the Canal is discouraged by the DOH due to high levels of pesticides and heavy metals that are present in the water and accumulate in the tissues of organisms living in the Canal.<sup>80</sup>

The Ala Wai Harbor provides 663 berthing spaces, 85 moorings, one ramp, and 22 dry dock storage spaces.<sup>81</sup> The harbor provides boating opportunities for the Hawai'i Yacht Club, Waikīkī Yacht Club, the Royal Hawaiian Ocean Racing Club, and other recreational boat owners.

## 3.8 Land Use

The Ala Wai Watershed is home to a variety of land uses, both in urban and undeveloped areas. Land use is dictated primarily by

State Land Use designations, and further by County zoning designations.

### 3.8.1 State Land Use Districts

There are three different State Land Use Districts represented in the Ala Wai Watershed area. The majority of the land is in the Urban District, which encompasses approximately 55% of the watershed area. The Conservation District encompasses 44% of the watershed and the Agriculture District encompasses less than 1%. See Figure 4 for a map of State Land Use Districts.

The state Urban District encompasses approximately 10,714 acres (6.3 miles<sup>2</sup>) of the watershed.<sup>82</sup> Urban lands include those areas that are currently in urban use as well as a reserve area for prospective growth. Land uses include schools, commercial establishments, hospitals, and residential developments that extend to the boundary between the Urban and Conservation Districts. Waikīkī is a unique area within the Urban District in that it is considered a prime tourist destination, and thus a major economic engine, for the State.

The Urban District is highly developed. As a consequence, 1,123 acres, 11% of the total watershed area, is devoted to roads and highways.<sup>83</sup> A 1989 count estimated that approximately 250,000 vehicles/day travel through the watershed.<sup>84</sup> This estimate was

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<sup>79</sup> State of Hawaii Department of Land and Natural Resources Commission on Water Resource Management. (1990). *Hawaii Stream Assessment: A Preliminary Appraisal of Hawaii's Stream Resources*.

<sup>80</sup> State of Hawaii Department of Health (1999, March 31). *Department of Health Publishes Multilingual Fish Advisory*.

<sup>81</sup> Department of Land and Natural Resources Division of Boating and Ocean Resources website <http://www.state.hi.us/dlnr/dbor/oahuharbors/alawaihrbr.htm>

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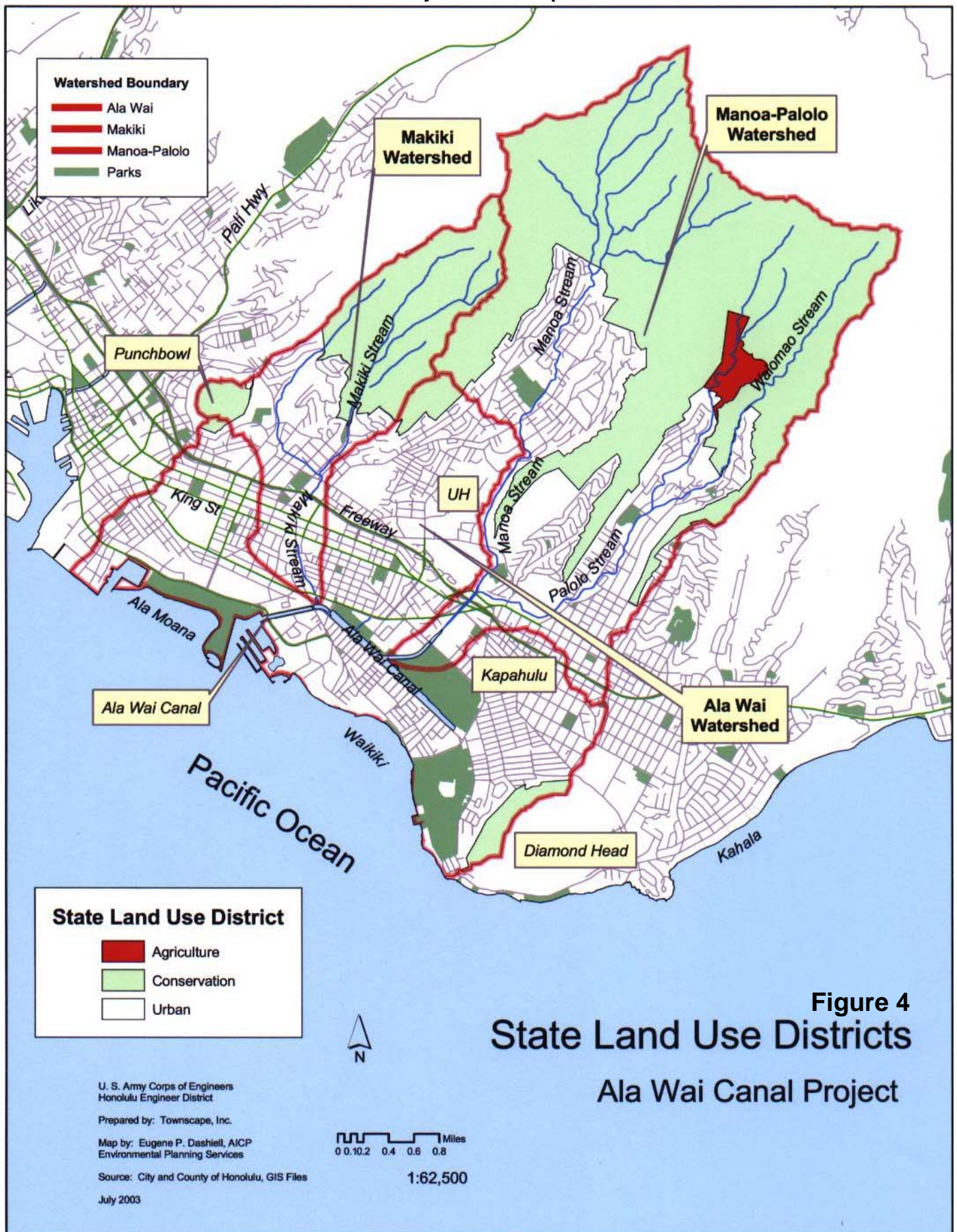
<sup>82</sup> State of Hawaii Department of Health. (1998). *Ala Wai Canal Watershed Water Quality Improvement Project Management and Implementation Plan Volume I*.

<sup>83</sup> Ibid.

<sup>84</sup> Ibid.



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vehicles has likely increased greatly since that time.

Agricultural lands are set aside for cultivation, with the greatest protection given to those lands with a high capacity of intensive cultivation. There is only a small, 105-acre area in Pālolo Valley that is designated as Agriculture.<sup>85</sup>

The Conservation District was established to protect forest and water reserve zones. In the Ala Wai watershed, these areas generally include those areas mauka of the Urban District, totaling 4,718 acres, or 7.5 square miles of the watershed.<sup>86</sup> The upper watershed is designated as the Honolulu Watershed Forest Reserve, and is maintained by the State.

#### 3.8.2 Land Ownership

Land ownership is divided amongst various entities and individuals. There are six entities that own parcels that are larger than 50 acres in size: the State of Hawai‘i, the City and County of Honolulu, Kamehameha Schools, the Honolulu Board of Water Supply, Punahou Schools, and the Mānoa Hillside Estates.

Land Owner	Acres
State of Hawai‘i	3,321
City and County of Honolulu	640
Kamehameha Schools	542
Honolulu Board of Water Supply	71
Punahou Schools	69
Mānoa Hillside Estates	53

<sup>85</sup> Ibid.

<sup>86</sup> Ibid.

#### 3.8.3 Flood Zones

The Federal Emergency Management Agency produces Federal Insurance Rate Maps (FIRM) that delineate those areas that are within flood inundation zones. Several flood control measures have been installed along all three major streams in the Ala Wai watershed and are discussed in Section 3.3.

Those areas that are within the 100-year flood hazard zones are generally associated with the urbanized portion of Mānoa Stream and the low lying areas of Mō‘ili‘ili, McCully, Waikīkī, and Ala Moana. See Figure 5 for a map of the FIRM flood zones. The Ala Wai Canal’s ability to accommodate flood flows is the greatest concern due to its location in a highly urbanized area and its proximity to Waikīkī. At its current capacity, the Ala Wai Canal has been found to have only marginal capacity to handle the 10-year or more frequent flood event and definitely could not handle the 100-year flood event.<sup>87</sup>

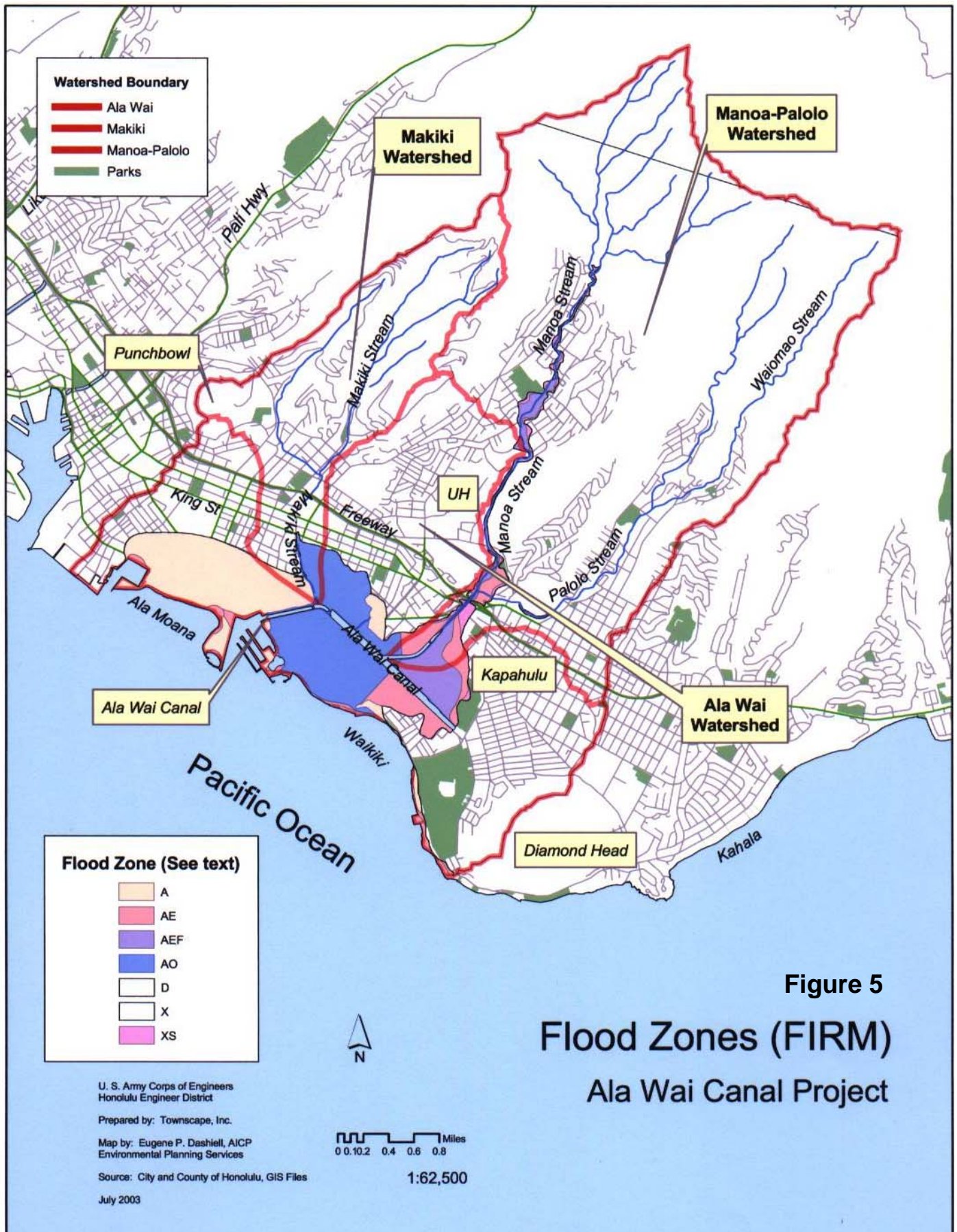
The Ala Wai Canal is currently being dredged of sediment to increase its sediment and storm water carrying capacity. Once dredging is complete in mid to late 2003, the 100-year flood levels in the Canal are expected to be lowered to “the approximately four feet to five feet msl elevation of the makai bank top.”<sup>88</sup>

<sup>87</sup> State of Hawaii Department of Land and Natural Resources Division of Water and Land Development. (1994). *Ala Wai Canal Improvement Project Storm Water Capacity Study, Honolulu, Oahu, Hawaii*.

<sup>88</sup> City and County of Honolulu Department of Transportation Services/Department of Design and Construction. (1998). *Ala Wai Canal Dredging Final Environmental Assessment*.



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#### 3.9 Management Structure

Management and maintenance of the Ala Wai watershed is fragmented amongst several government agencies and private land owners. Section 46-11.5 of the Hawai'i Revised Statutes (HRS) mandates that each county is responsible for the maintenance of "channels, streambeds, streambanks, and drainageways."<sup>89</sup> However, this responsibility is relinquished if the waterway is owned by the State, in which case the State is responsible for maintenance. Similarly, section 41-26.0 of the Revised Ordinances of Honolulu (ROH) private owners are responsible for the maintenance of their portion of waterway to assure unimpeded flow.<sup>90</sup> The upper watershed is within the State Conservation district and is under the jurisdiction of the DLNR. Land within the Urban District of the watershed is divided amongst various landowners, both public and private. Therefore, management is broken up amongst many individuals and agencies, based on land ownership. See Appendix B for an overview of Agency Profiles and Watershed Programs.

Additionally, management is further complicated by the missions of various federal, state, and county agencies to protect

different aspects of the watershed. For example, the Federal Clean Water Act is regulated by the U.S. Environmental Protection Agency (USEPA) but is administered at the local level by the HI DOH. Several agencies such as the HI Department of Transportation and the C&C ENV are also involved in water quality through the administration of National Pollutant Discharge Elimination System (NPDES) permits. Additionally, the Federal Coastal Zone Management program, administered by the State, protects those area not covered by the NPDES program.

The scientific community holds a distinctly different, yet necessary role in the management of the Ala Wai. Researchers are continuously generating new data and developing models to better understand watershed processes. Their research is essential in developing priorities, identifying problems and solutions, and evaluating the results of actions.<sup>91</sup>

Citizen's groups also contribute valuable resources toward watershed management. In addition to the county-sponsored neighborhood boards and vision teams, several non-profit organizations such as the Ala Wai Watershed Association and the Ko'olau Mountains Watershed Partnership provide expertise and volunteer coordination.

While there is a myriad of watershed-related agencies and organizations, it is still difficult to improve conditions. This is in part

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<sup>89</sup> State of Hawaii. *Hawaii Revised Statutes Subtitle I, Provisions Common to All Counties, Chapter 46, General Provisions, Section 11.5, Maintenance of Channels, Streambeds, Streambanks, and Drainageways.*

<sup>90</sup> City and County of Honolulu. (2002-2003) *Revised Ordinances of Honolulu, Chapter 11, Regulated Activities Within the City, Article 26, Maintenance of Channels, Streambeds, Streambanks and Drainageways.*

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<sup>91</sup> U.S. Environmental Protection Agency. (2002, December 11). *The Watershed Approach*

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because agencies are only able to affect those areas physically and programmatically allowed them by law, while watershed issues tend to cross jurisdictional boundaries. Additionally, overlapping programmatic and geographic jurisdictions can lead to confusion over responsibility, duplication of effort, and ultimately, an inefficient use of resources.

The complexity and interconnectedness of watershed functions requires an overall body that is able to take a holistic view of the entire area. This not only requires an entity that has decision-making capabilities, but also the technical expertise and the ability to work with and for the local community.